CASTNET Update

2020 MARAMA Monitoring Workshop
December 9, 2020

Timothy Sharac, Melissa Puchalski, and Gregory Beachley

US Environmental Protection Agency

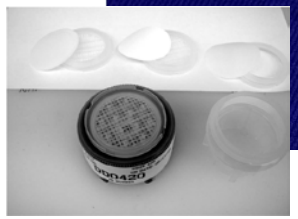
Office of Atmospheric Programs

Outline

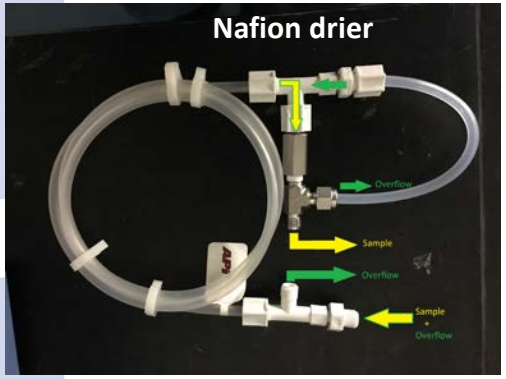
- CASTNET Overview
- NADP Overview
- Operational Impacts from COVID-19 Restrictions
- Other Impacts to Monitoring in 2020
- Preliminary 2020 CASTNET Ozone Observations
- Novel Uses of CASTNET and NADP Infrastructure
- Evaluation of NHx Measurements
- Summary

CASTNET Overview

- Network provides data to assess **long-term**, **regionally representative trends** in **sulfur, nitrogen, and O_3** pollutants
  - Gas & particle concentrations in air are measured weekly on filters and used to estimate dry deposition
  - Continuous O_3 concentrations measured to support NAAQS determinations
  - A subset of sites also operate NO/NOy, CO, and SO_2
  - Thirty O_3 analyzers use Nafion driers for moisture control
- Sites are located away from known emissions sources (e.g., EGUs) and often in ecologically important locations including 30 National Parks and Monuments
- Consistent measurements with a robust QA program

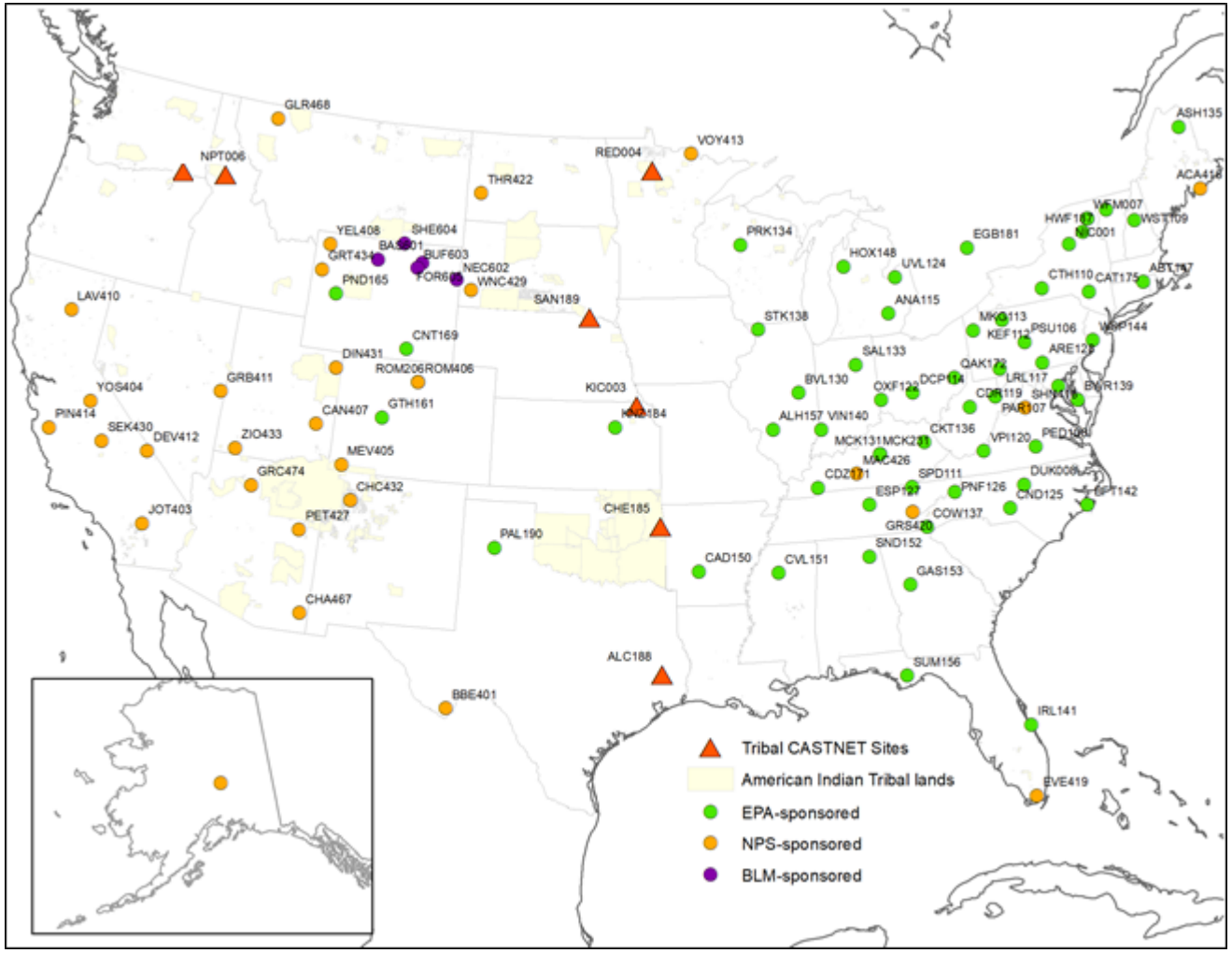


Gases	Particles
• HNO_3	• NO_3
• O_3	• NH_4^+
• NO/NO_y	• SO_4^{2-}
• SO_2	• Base Cations
• CO	• Cl^-



CASTNET Monitoring Network

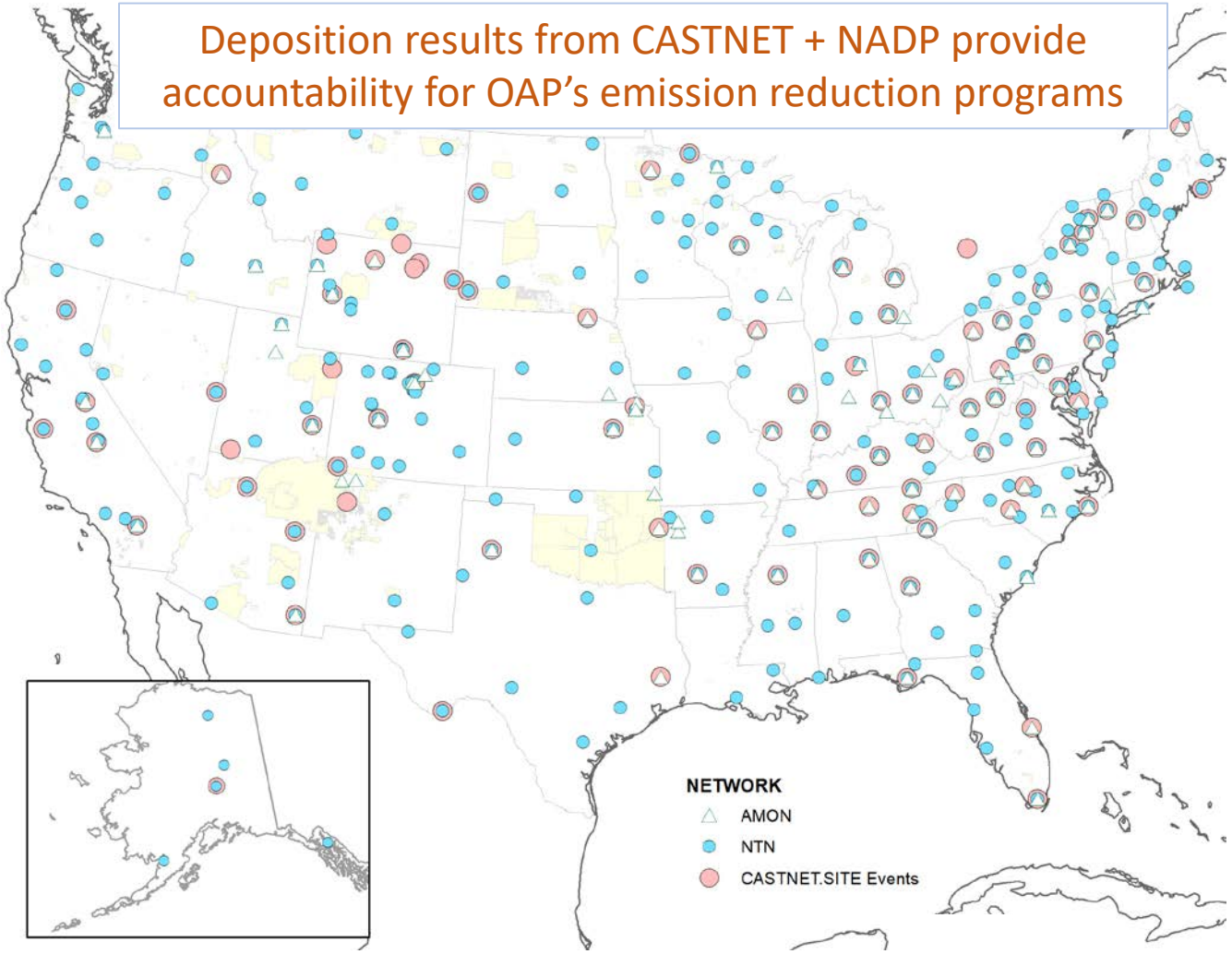
- **Established in 1987**
  - 99 rural monitoring sites
    - Umatilla (UMA009) added last month
  - 87 ozone analyzers
  - 41 sites w/30+ years of data
  - Usually collocated with NADP
- **Network design**:
  - Rural, away from large emission sources
  - National coverage, regionally representative for baseline ozone measurements



National Atmospheric Deposition Network (NADP)

- Program established in 1978 to measure pollutants in precipitation (acid rain)
  - **National Trends Network (NTN)** measures weekly wet deposition of SO_4^{2-}, NO_3^-, NH_4^+, pH, cations, Cl^- at more than 250 sites
  - Nearly all CASTNET sites are co-located or near an NTN site
- Mercury Monitoring
  - **Mercury Deposition Network (MDN)** provides weekly wet deposition of Hg
  - **Atmospheric Mercury Network (AMNet)** provides concentrations of speciated gaseous Hg
- Ammonia Monitoring
  - **Ammonia Monitoring Network (AMoN)** provides bi-weekly concentrations of ambient NH_3
  - Network was established in 2007 and has grown to more than 100 sites
  - Over 60 AMoN sites co-located with CASTNET

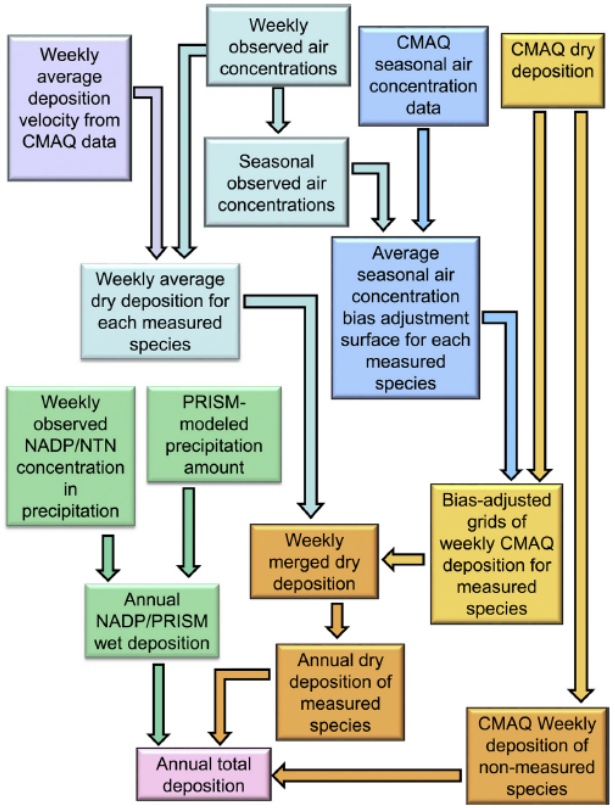
Deposition results from CASTNET + NADP provide accountability for OAP's emission reduction programs



Total Deposition Measurement Model Fusion (MMF)

National Atmospheric Deposition Program Total Deposition Science Committee (NADP/TDep) model that produces annual gridded deposition estimates from 2000 to 2019 (updated annually)

Includes wet, dry, and total N and S deposition for specific species frequently used in Critical Loads and ecological assessments



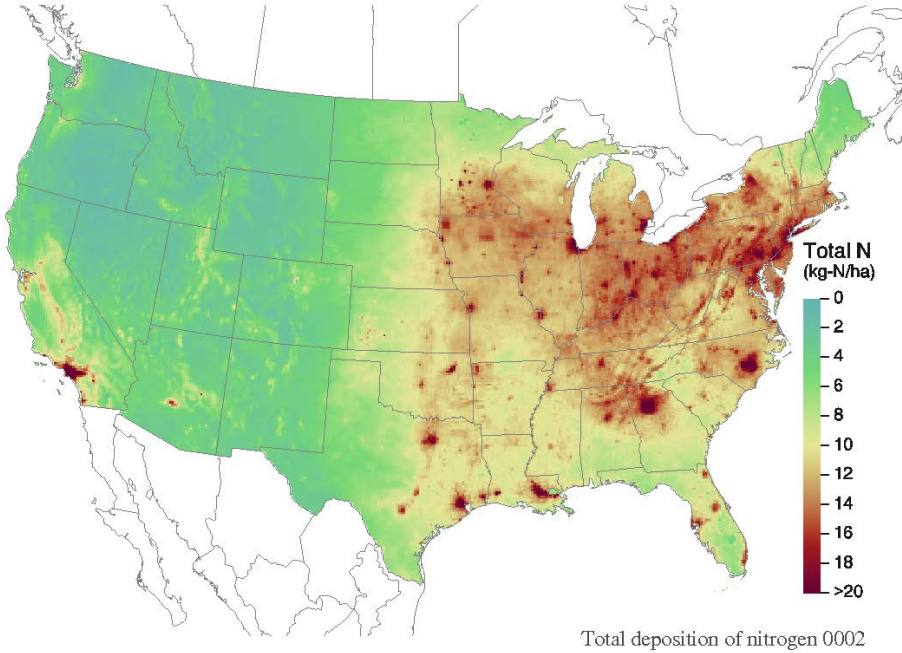
Schematic on TDep MMF protocol
(*adapted from Schwede and Lear, 2014)*

- ***Measurement Data:***
  - *Weekly CASTNET filterpack*
  - *Weekly NADP NTN precipitation concentrations*
- ***Modeled Data:***
  - *CMAQ weekly concentrations, dry deposition, and deposition velocities*
  - *PRISM annual precipitation*

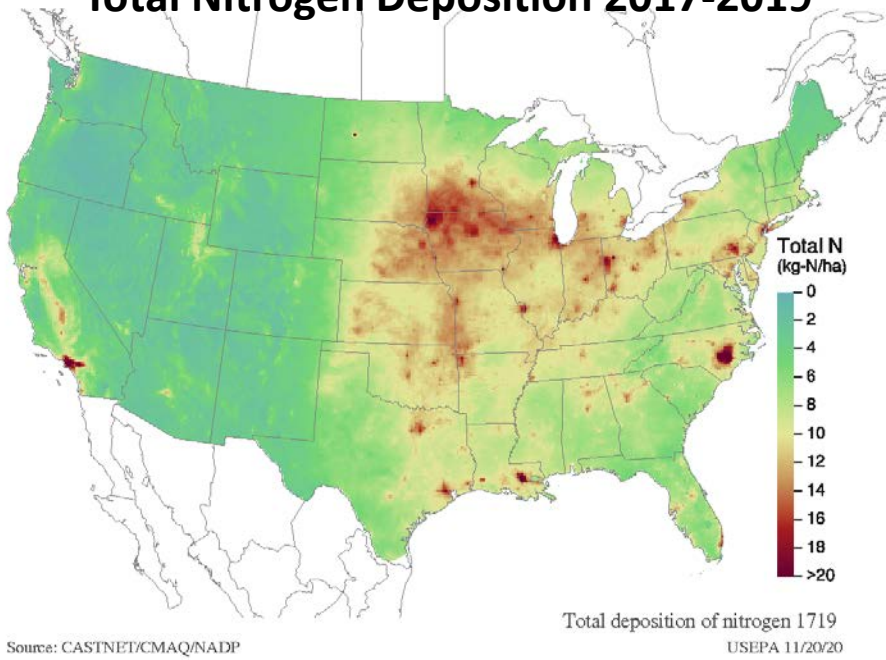
Gridded data and images available on NADP/TDep website http://nadp.slh.wisc.edu/committees/tdep/tdepmaps/

Currently modernizing script to ArcPy/ArcGIS Pro which will be publicly available

Total Nitrogen Deposition 2000 - 2002

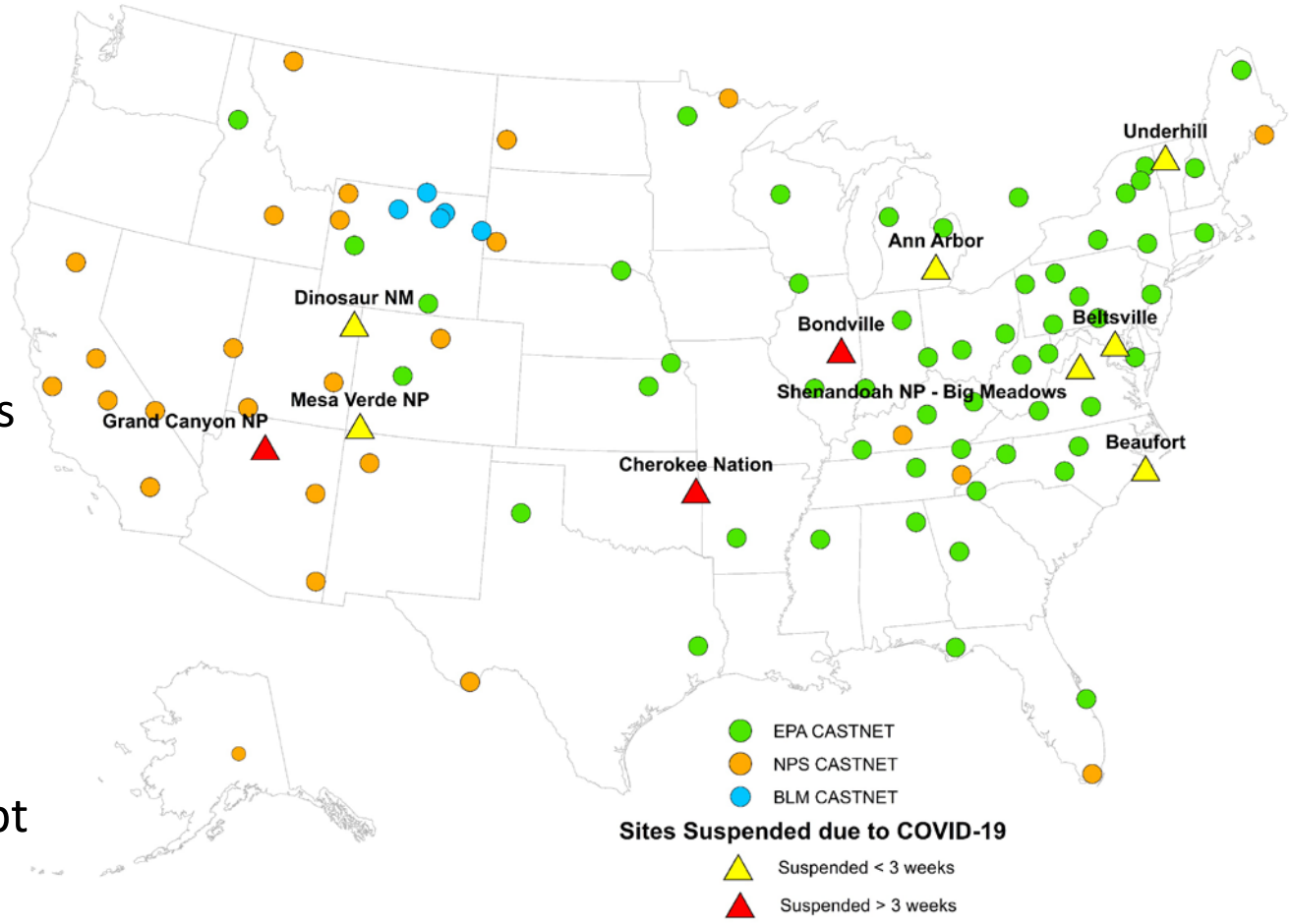


Total Nitrogen Deposition 2017-2019



Operational Impacts from COVID-19 Restrictions

- Monitoring deemed essential by EPA. Memo was signed on March 18th *Ambient Air Monitoring Programs Continuity of Operations Associated with the COVID-19 Response*
  - EPA, NPS and BLM shared memo with CASTNET operators
- Site sponsors, operators, and auditors worked together to follow CDC guidelines and local mandates (e.g., universities)
- Overall, monitoring operation impacts was minimal, considering the circumstances
- 6-month calibrations and independent annual audits were suspended in March and April
  - All calibrations and annual audits resumed except for Canadian sites, AK97, MA08



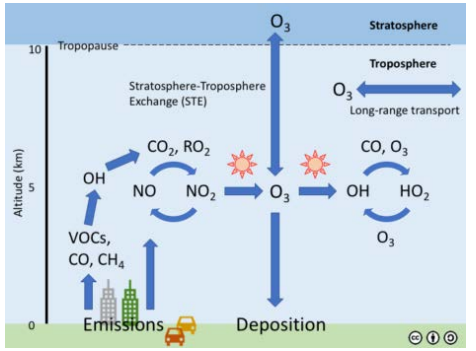
Other Impacts to 2020 Monitoring

- Record wildfires:
  - SEK430, CA; YOS404, CA; JOT403, CA; NPT006, ID; and CNT169, WY were impacted by wildfires
  - CNT169, WY monitoring equipment was pulled due to wildfire risk from Oct 7 - 21.
  - 36 ozone exceedances between August 21-23 from CA to WY
  - Otherwise National Park Service reported that PM formation from wildfires ended up preventing ozone conducive conditions due to blocking out solar radiation
- Record hurricanes:
  - SUM156, FL sustained damage from Hurricane Sally
- Record heat:
  - Death Valley (Furnace Creek) recorded the hottest temperature in world history at 129.9F on August 16th, 2020
- Site relocation:
  - Horton Station, (VPI120) - Giles County, VA (51-071-9991) was moved due to land sale
  - Chuck Turner (VA-DEQ), the current site operators, and two potential landowners all helped find a replacement site
  - The new AQS ID is 51-071-9992-1, but the data record will overlap with old AQS ID (51-071-9991-1)
  - The site was out of commission for two weeks (July 22 - August 6)

Preliminary 2020 CASTNET Ozone Observations

Objective: Identify and quantify changes to CASTNET ozone resulting from COVID-19 related stay-at-home orders and related societal changes

Hypothesis: COVID-19 related stay-at-home orders have resulted in reduced ozone precursor emissions, which in turn resulted in significantly lower ozone concentrations in 2020 when compared with the 2015-2019 ozone record



https://www.ladco.org/public-issues/ozone/

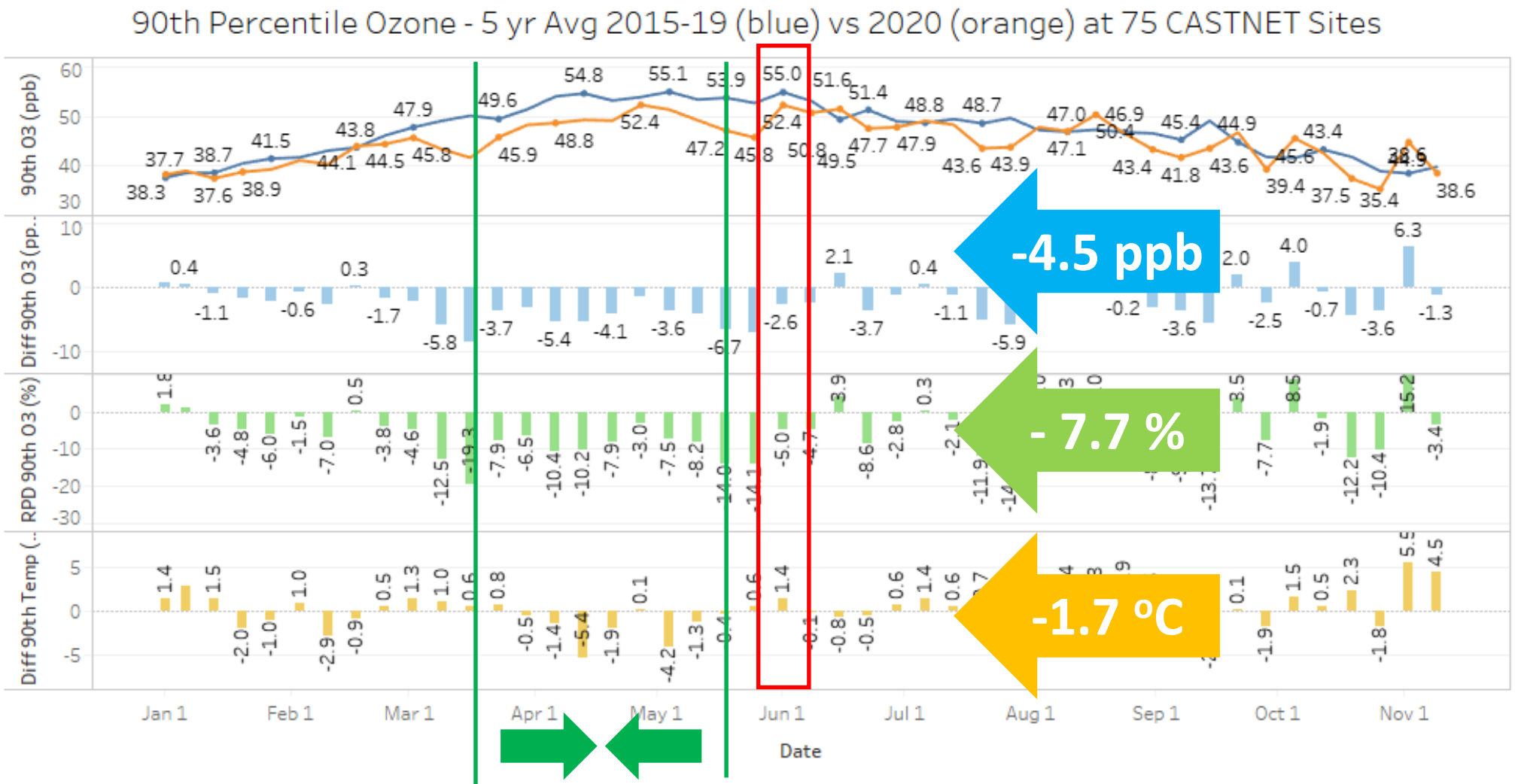
Caveats:

- Much of these data are ***preliminary*** and have not been fully QA'd
- Ozone concentrations fluctuate from year to year due to meteorological (e.g. temperature fluctuations, precipitation/washout) and wildfire impacts (e.g., may have either positive or negative impacts to ozone formation as a result of fire intensity and smoke formation)
- Ozone levels decline over time due to current air regulations
- Stay-at-home orders varied significantly in terms of timing, duration, and implementation

Methods:

- We derive site-level, weekly 90th percentiles for both 1-hour ozone and temperature values and compare the 2020 values against averaged weekly percentiles from 2015-2019
- We examine stay-at-home orders to look for temporal changes
- We use DOT's vehicle miles traveled and NOAA climate maps for spatial patterns

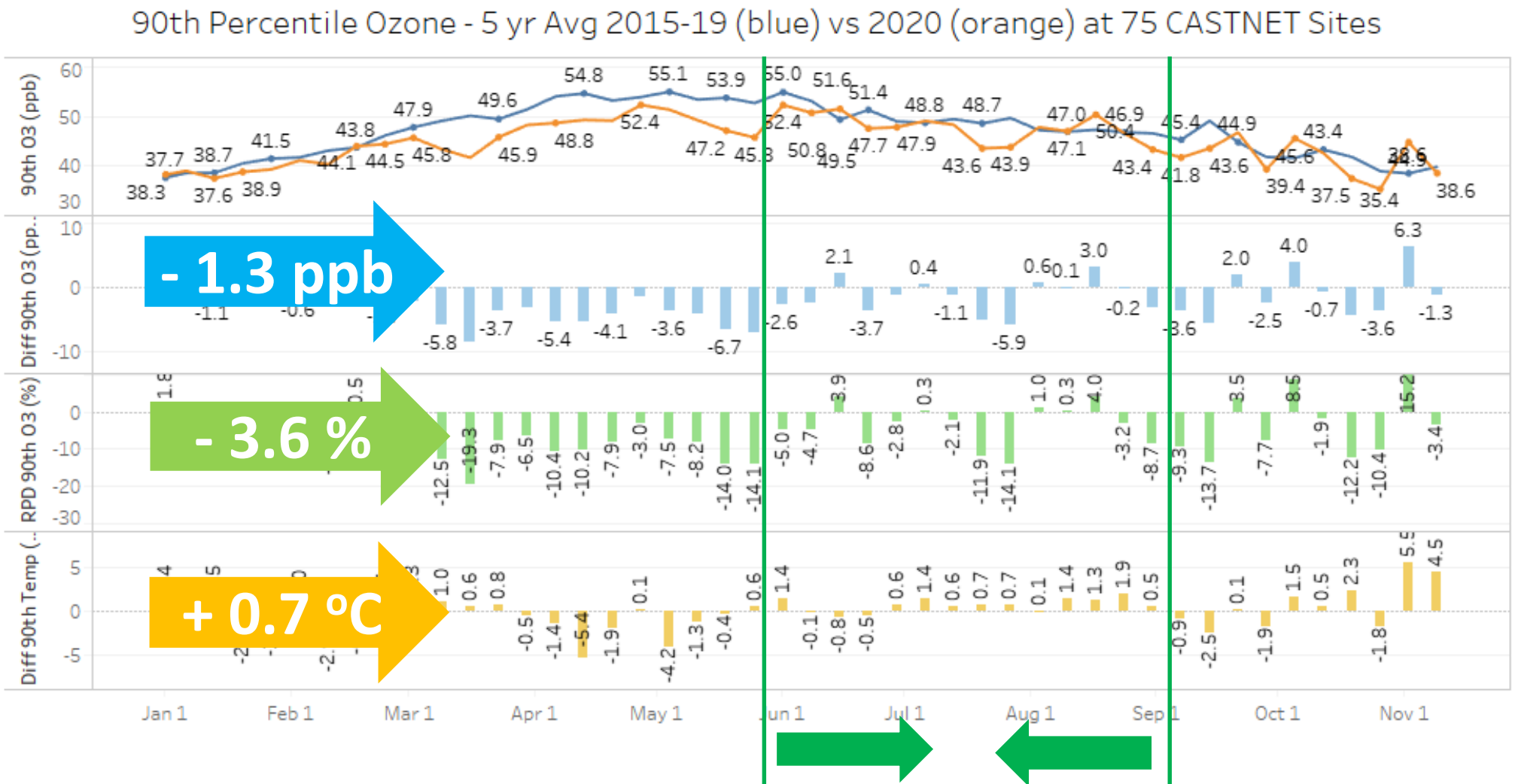
Preliminary 2020 CASTNET Ozone Observations
January 1 – November 15, 2020



Period 1

Average state-wide shutdown period = March 23 – May 17

Preliminary 2020 CASTNET Ozone Observations
January 1 – November 15, 2020

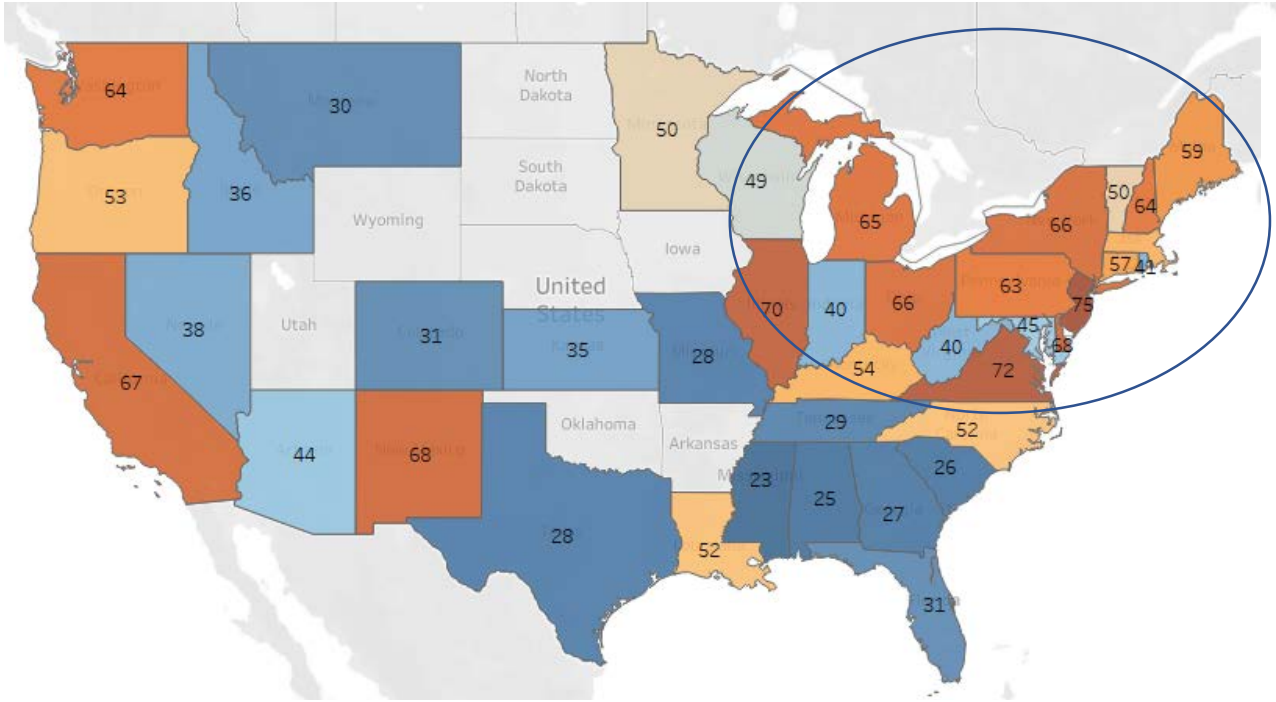


Period 3

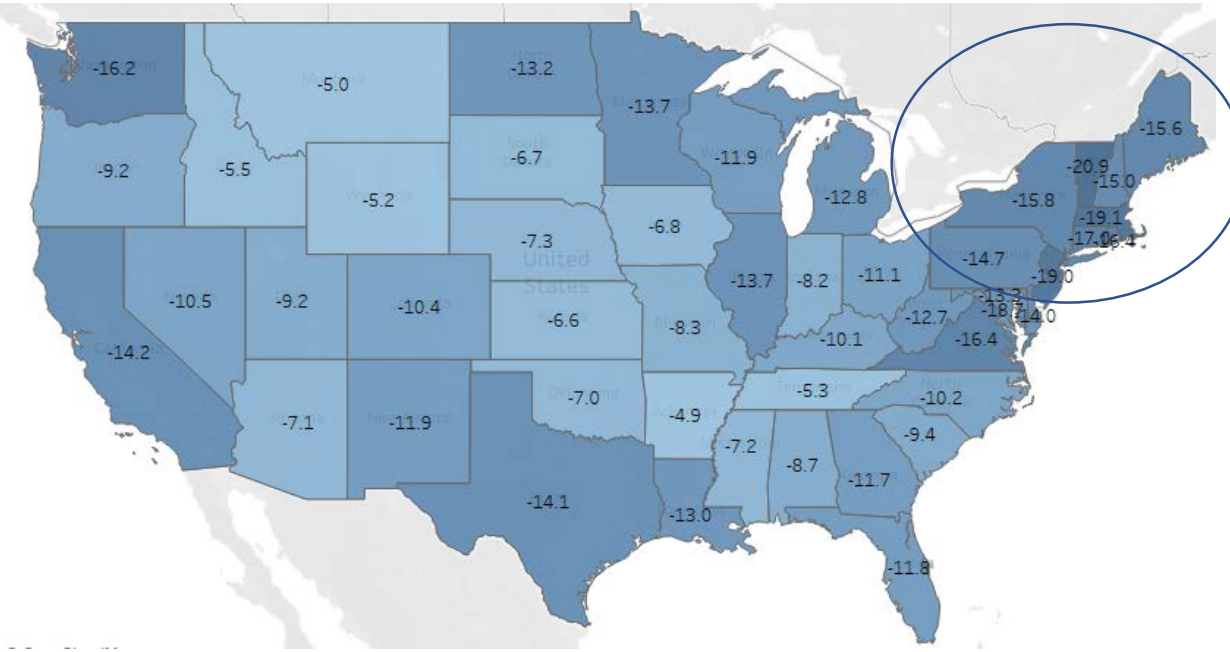
"Summer" months = June 1 – Sept 6

Stay-at-home Order Duration
DOT – Summer Vehicle Miles Traveled

Stay-at-home Order Duration



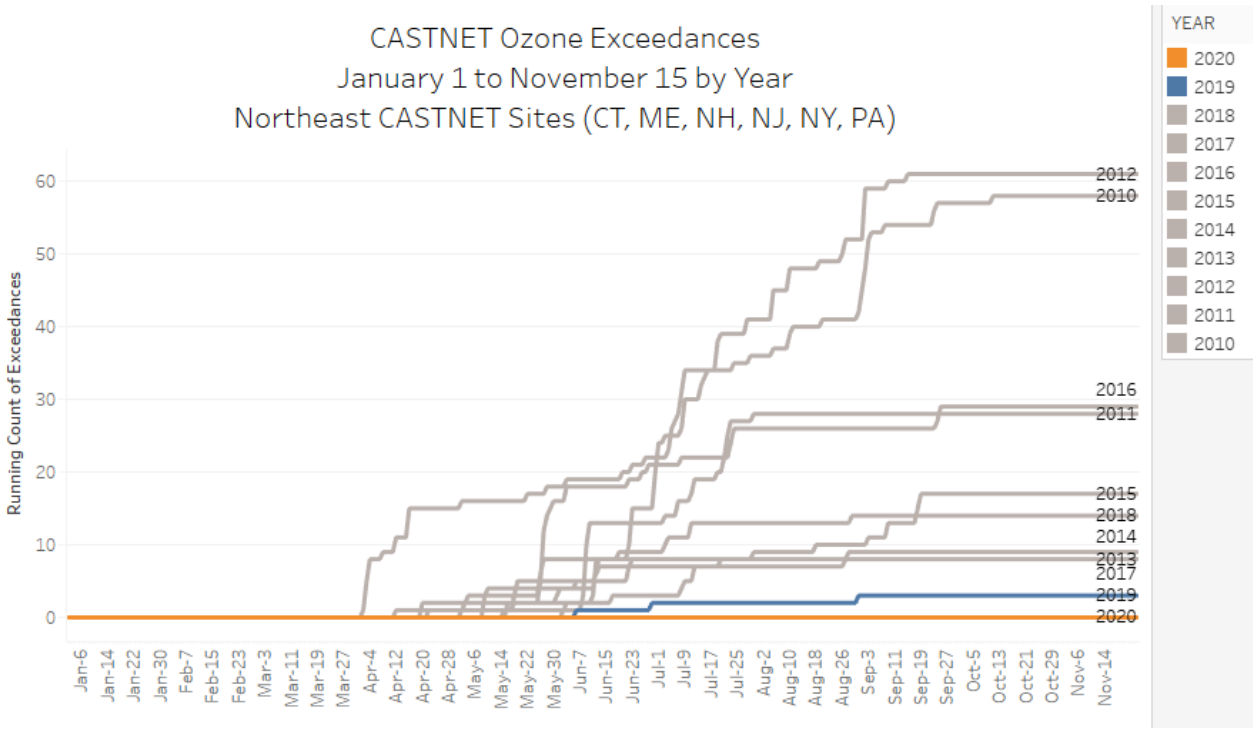
June – August 2020 vs 2019 VMT % Change

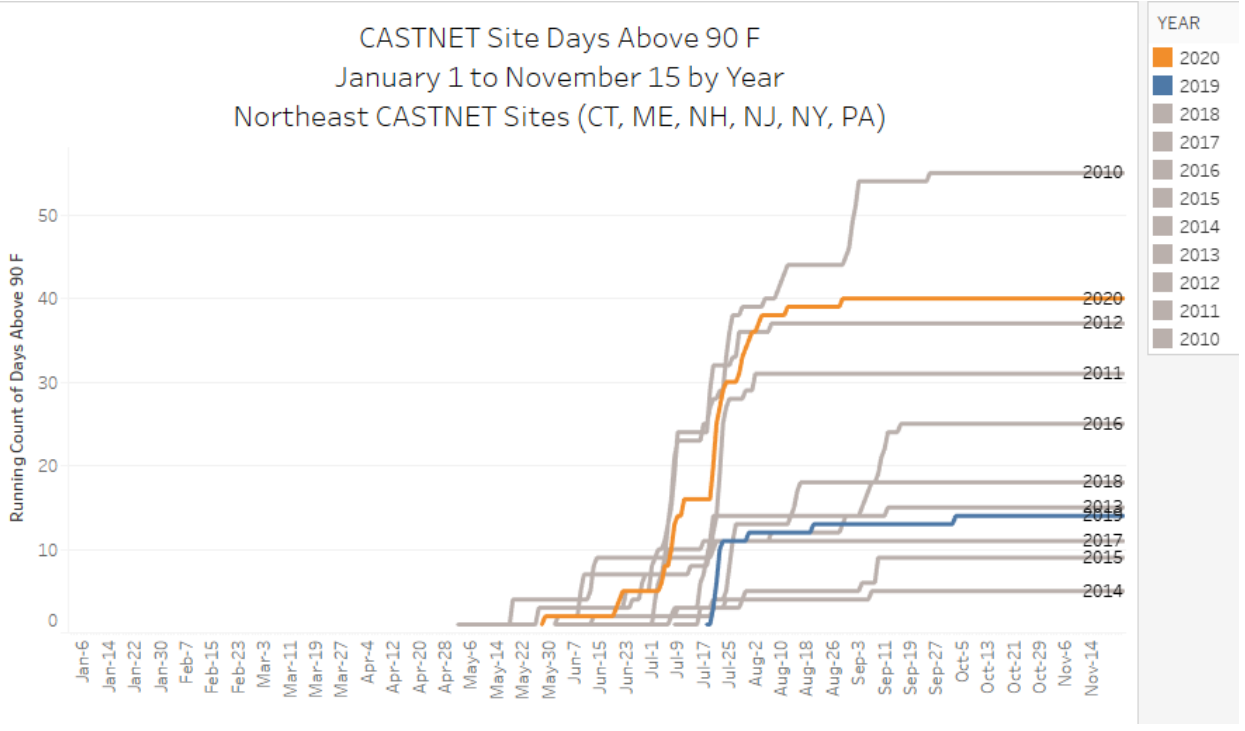


https://www.nytimes.com/interactive/2020/us/states-reopen-map-coronavirus.html

https://www.fhwa.dot.gov/policyinformation/travel_monitoring/tvt.cfm

Preliminary 2020 CASTNET Ozone and Temperature Observations Cumulative Ozone Exceedances and Days above 90 F – 2010 – 2020 Across 11 Northeastern CASTNET Sites





2020 had the **fewest ozone exceedances** of the 2015 NAAQS on record, zero

2020 had the **second highest count of site days above 90 degrees** since 2010; fifth highest on record

Possible Ozone Reductions Due to Stay-at-home Orders

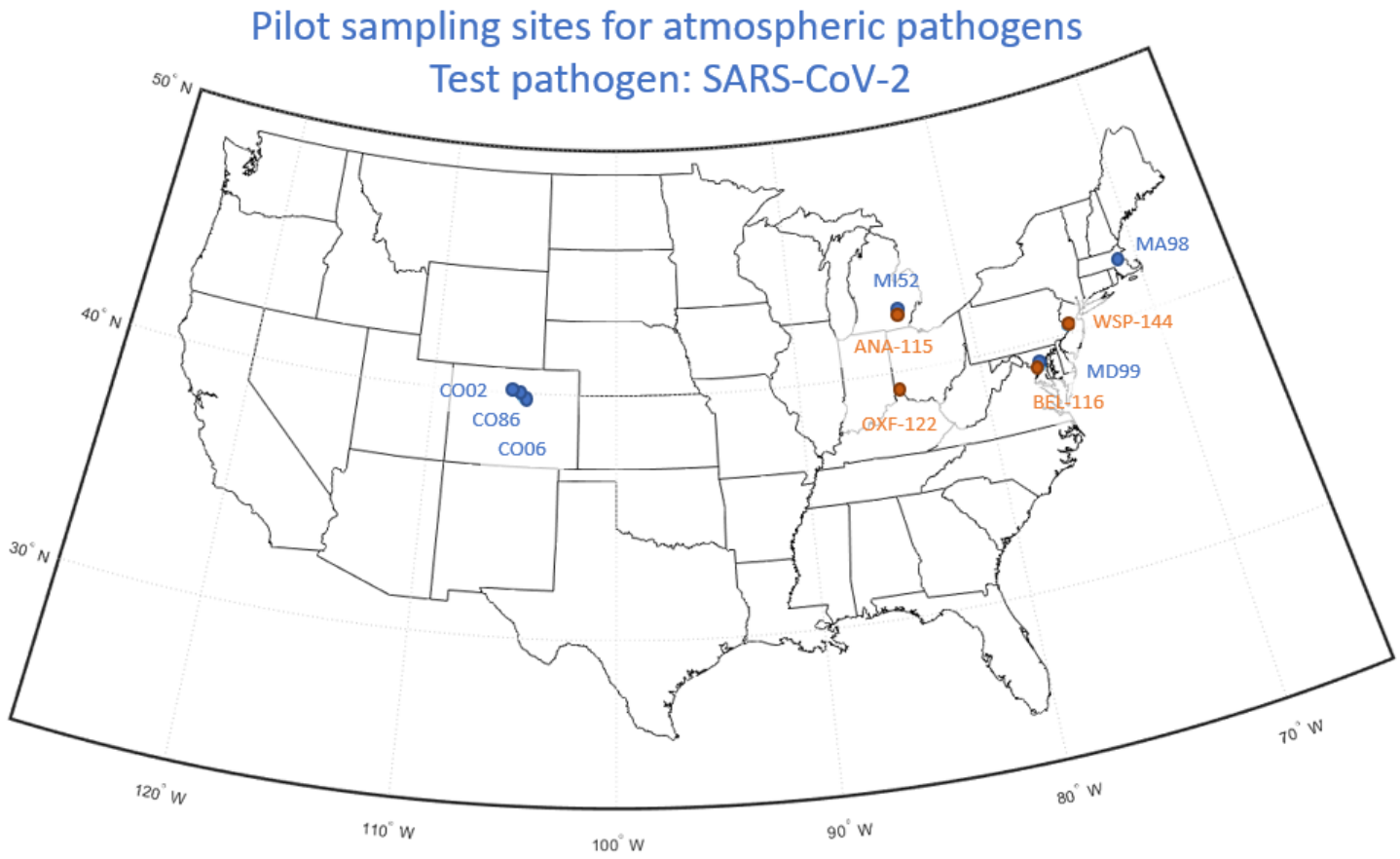
The Northeastern states (PA, NJ, NY, MA, CT, RI, VT, NH, and ME) had:

- Longest stay-at-home order duration
- Largest reduction in summer vehicle miles traveled between 2020 vs 2019
- Above average temperatures and below average precipitation (e.g., ozone conducive)
- Least likely to have been impacted by record wildfire or hurricane seasons

Time Period	Region	Site Qty	Avg P90 RPD	Avg P90 Diff	Ozone P-Value	Avg P90 Temp Diff	Temperature P-value
Post stay-at-home	Northeastern	11	-4.0 %	-1.8 ppb	2.18E-05	0.5 C	8.22E-03
Summer	Northeastern	11	-3.6 %	-1.6 ppb	7.26E-05	1.1 C	3.00E-09

Utah State University COVID-19 study

- Dr. Janice Brahney at Utah State University is performing analysis on CASTNET and NADP/NTN samples to detect SARS-CoV-2 RNA
- Is it possible to detect the virus in existing ambient samples?
- qPCR analysis
  - Used to detect virus in hospitals in Wuhan, China
  - Presence in Teflon extracts from CASTNET and NTN precipitation
  - Sampling ran from summer into November 2020



Dr Janice Brahney

Utah State University COVID-19 study (cont.)

- CO06: 33% positive, n=9
- MI52: 22% positive, n=9
- MD99: 29% positive, n=7
- NY06: 50% positive, n=4
- MA98: 25% positive, n=4
- Lakewood (backyard): 100% positive, n=2
- CO02: 50% positive, n=8
- WSP144: 42% positive, n=12
- BEL116: 33% positive, n=9
- ANA115: 25% positive, n=12
- OXF122: 100% positive, n=1

NADP/NTN Monitoring Work on PFAS in Precipitation

NCON precipitation collection with modified procedure: MeOH rinse after collection

- EPA's Office of Research and Development study to use NADP NTN samplers for PFAS monitoring
- Analysis performed at NADP's Wisconsin laboratory
- Fall 2020 sampling began:
  - Whiteface Mountain, NY (NY98)
  - Washington Crossing, NJ (NJ99)
  - Duke Forest, NC (NC30)
  - Freeport, ME (ME96)
- Purpose is to identify **source emissions**, ambient distributions, chemical transformations, phase transfers, **transport, deposition**, & relative roles of each? Can we understand & quantify how well we measure each?
- Previous NADP pilot study at 30 sites analyzed in Spring/Summer 2019
  - Concentrations were low for individual compounds, but the sum of 36 compounds exceeded 4 ng/L at several sites

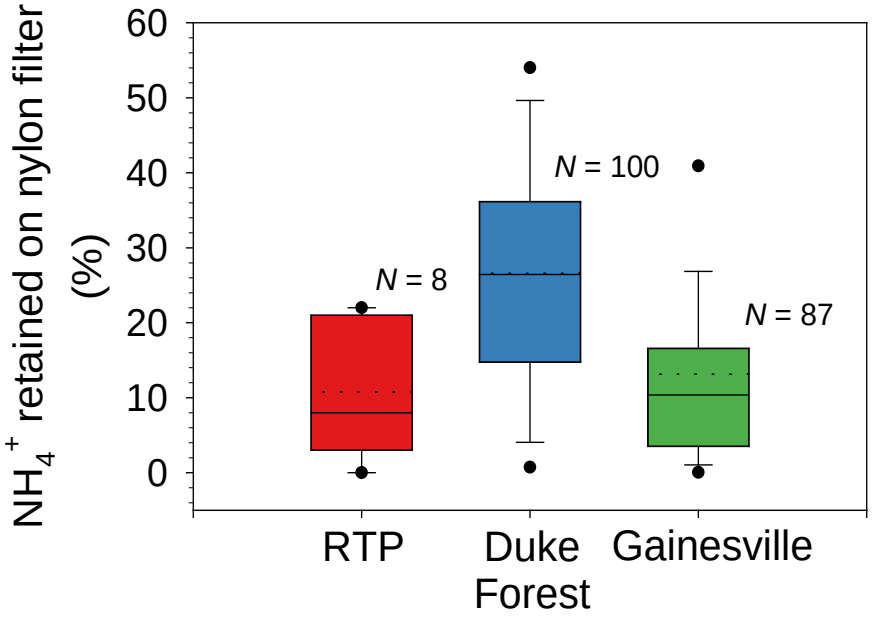
Evaluation of NHx Measurements

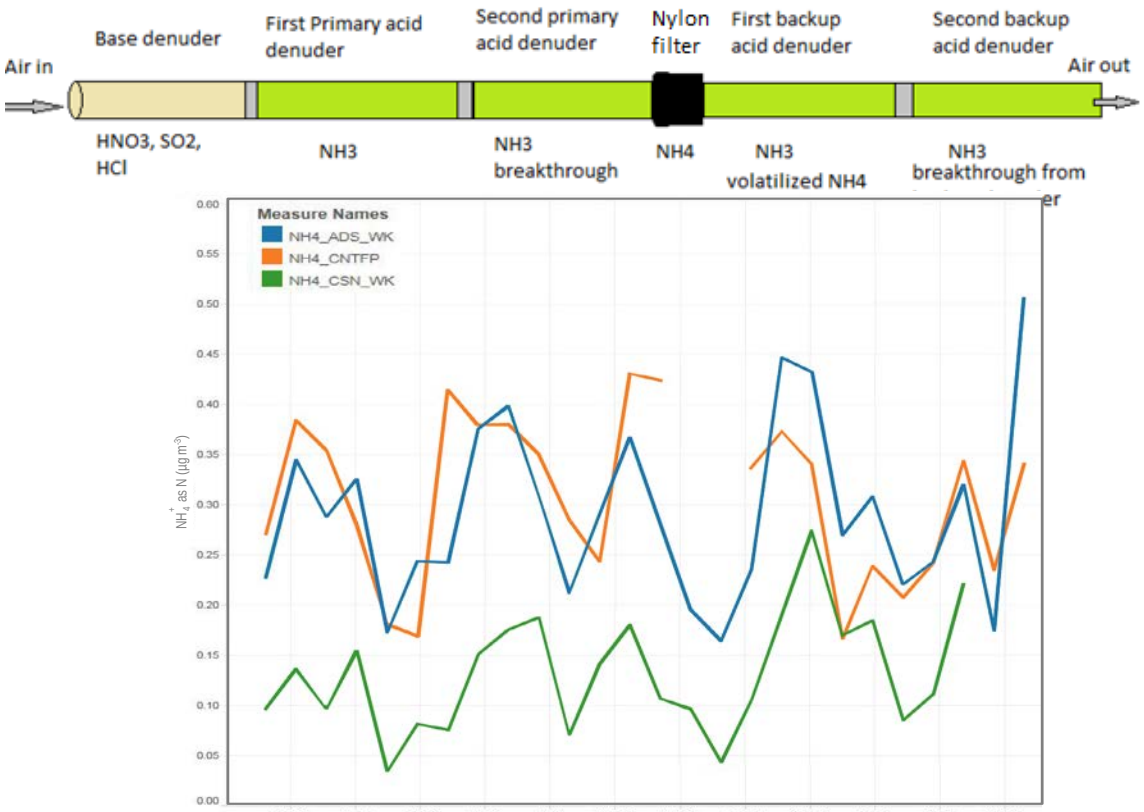
- **EPA-OAQPS funded study to evaluate whether CSN and IMPROVE monitoring equipment could be adapted to measure NHx**
- **Used acid-coated annual denuder filter pack system (ADFPS) (URG Corp) as reference method**
- **NHx results were comparable, but NH_4^+ was showing poor capture efficiency compared to ADFPS**
- IMPROVE and CSN measure ions on nylon filters
  - **IMPROVE does not report NH_4^+ due to this known bias**
  - **CSN likely under-reporting NH_4^+ measurements** (next slide)
  - CASTNET measures NH_4^+ on Teflon filter
  - ADFPS used nylon filter for this study
- **Write up of the results expected in early 2021**

Yu et al., 2005. Particulate Nitrate Measurement Using Nylon Filters

Evaluation of NHx Measurements (cont.)

Ammonium retained on the nylon filter as percent of total (nylon filter plus NH_3 captured on the backup denuder from volatilized NH_4^+). Boxes represent the 25th and 75th percentile, the solid and dashed lines within the box represent the median and mean, respectively, the whiskers represent the 10th and 90th percentiles, and dots represent the 5th and 95th percentiles.





Time series from Duke Forest of NH^+_4 concentrations from ADFPS (blue), CASTNET (orange - Teflon), and CSN (green - nylon). ADFPS and CSN concentrations are weekly averages matching the CASTNET sampling period.

Summary

COVID-19 stay-at-home orders had minimal impacts to the operations of CASTNET and NADP, but temporarily prevented 6-month calibrations and annual audits in March and April. Calibrations and annual audits have largely resumed aside from the Canadian sites, AK97, and MA08.

Stay-at-home orders occurred during a cooler than average Spring, greatly challenging the distinction between meteorological impacts and stay-at-home impacts to ozone reductions across the US.

Comparatively longer stay-at-home orders, larger reductions in vehicle miles traveled, and minimal impacts from wildfires and hurricanes across the Northeastern US appear to align with summer ozone reductions, despite above average temperatures.

CASTNET and NADP continue to partner with researchers to explore novel data products including improving our understanding of NHx, PFAS, and COVID-19 RNA sampling

Disclaimer

The views expressed in this presentation are those of the author and do not necessarily represent the views or policies of the U.S. Environmental Protection Agency

Timothy Sharac
sharac.timothy@epa.gov
202-343-9180

New Opportunity

Keep an eye on @EPAairmarkets

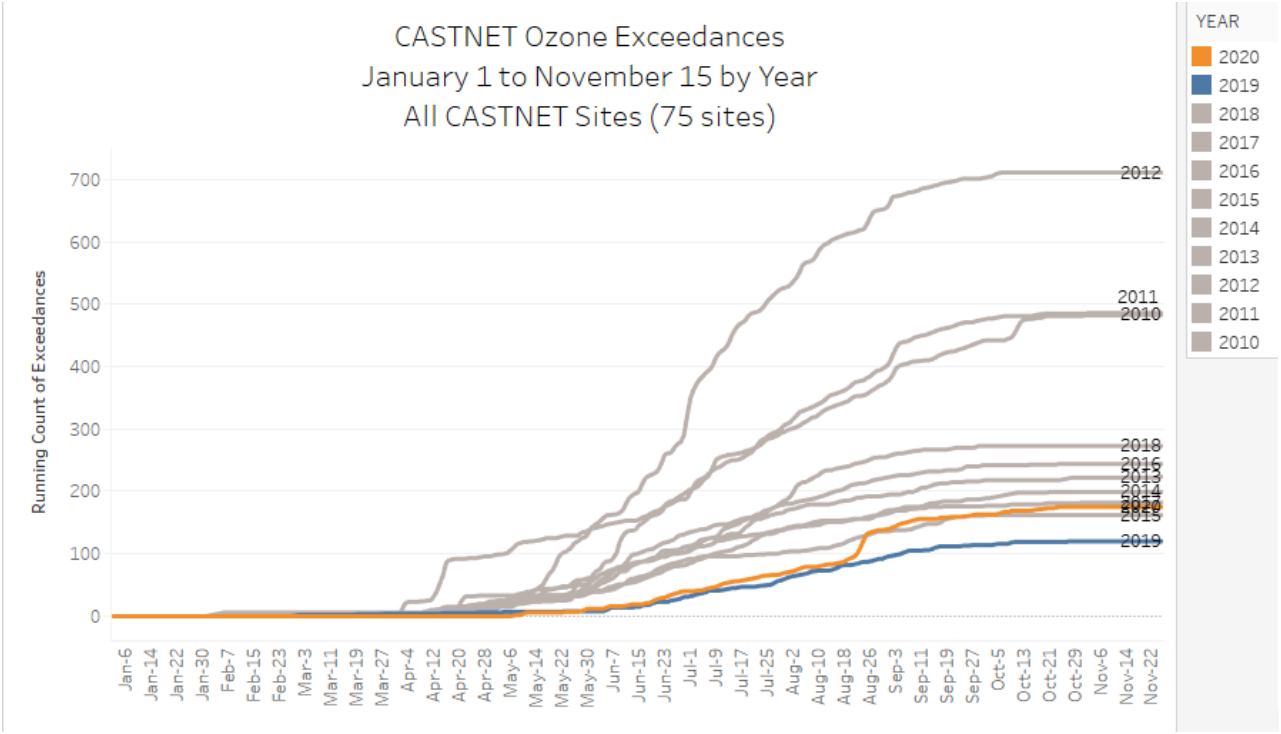
3rd EmPOWER Air Data Challenge

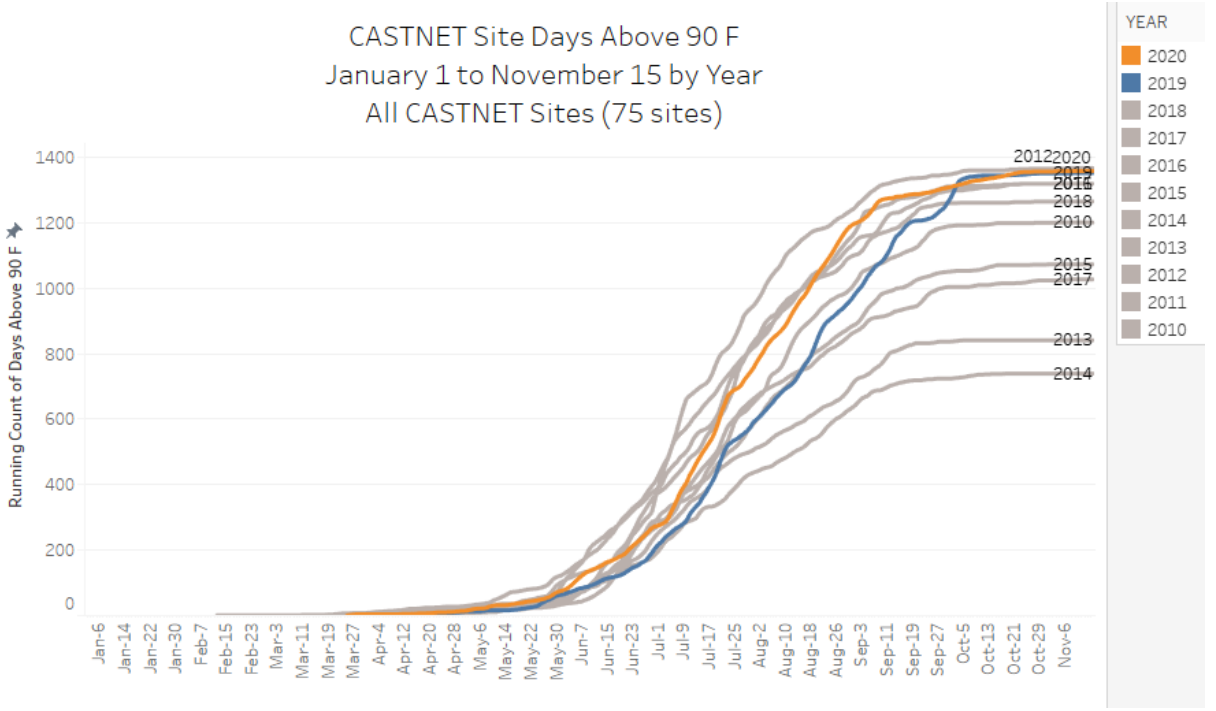
- Submit ideas for creative analyses using EPA's emissions and/or environmental monitoring data (CAMD's Power Sector Emissions Data, CASTNET, and/or LTM)
- Work with EPA experts to use and understand the data during the 2021-2022 academic year
- Open to researchers at universities or think tanks
- Application period now open, closes February 22

Contact Justine Huetteman at huetteman.justine@epa.gov with questions.

Appendix

Preliminary 2020 CASTNET Ozone and Temperature Observations Cumulative Ozone Exceedances and Days above 90 F – 2010 – 2020 Across 75 CASTNET Sites

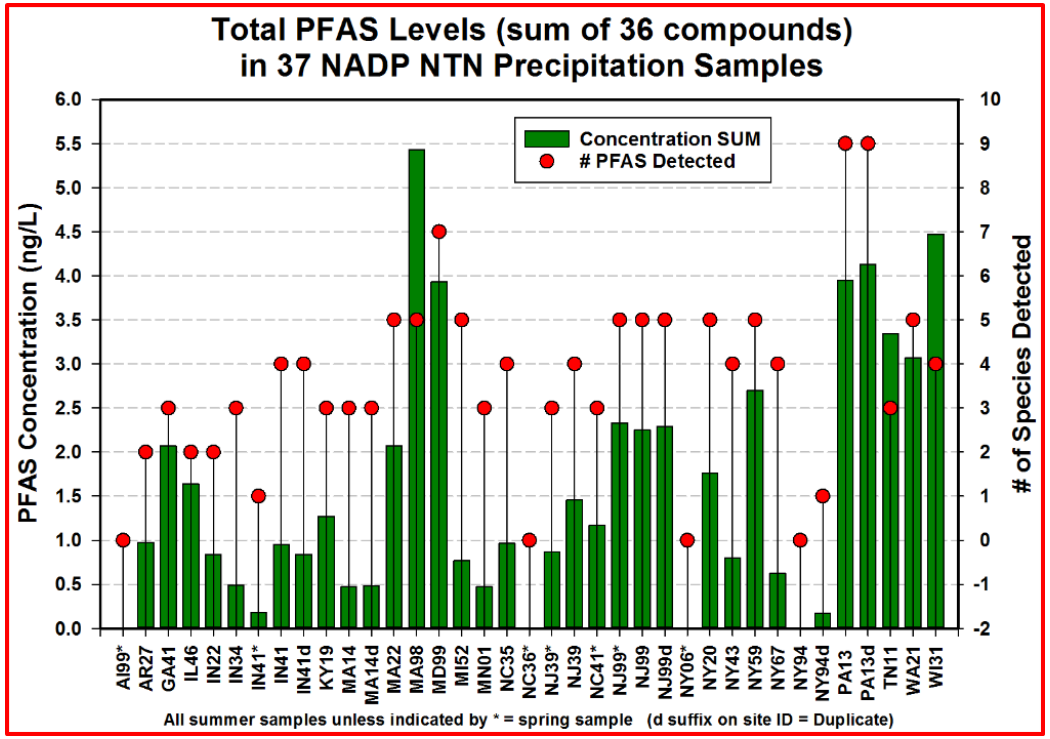




2020 had the **third fewest ozone exceedances** of the 2015 NAAQS on record

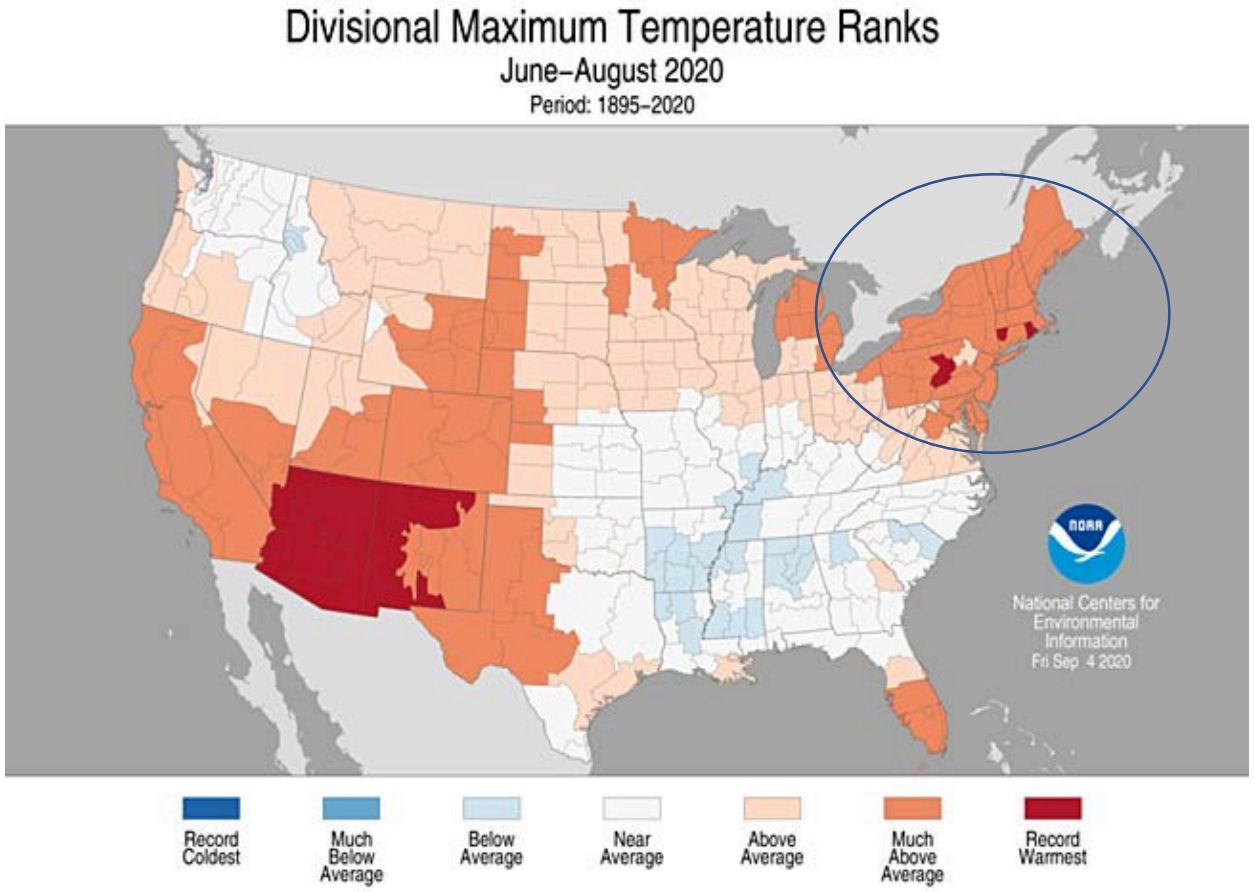
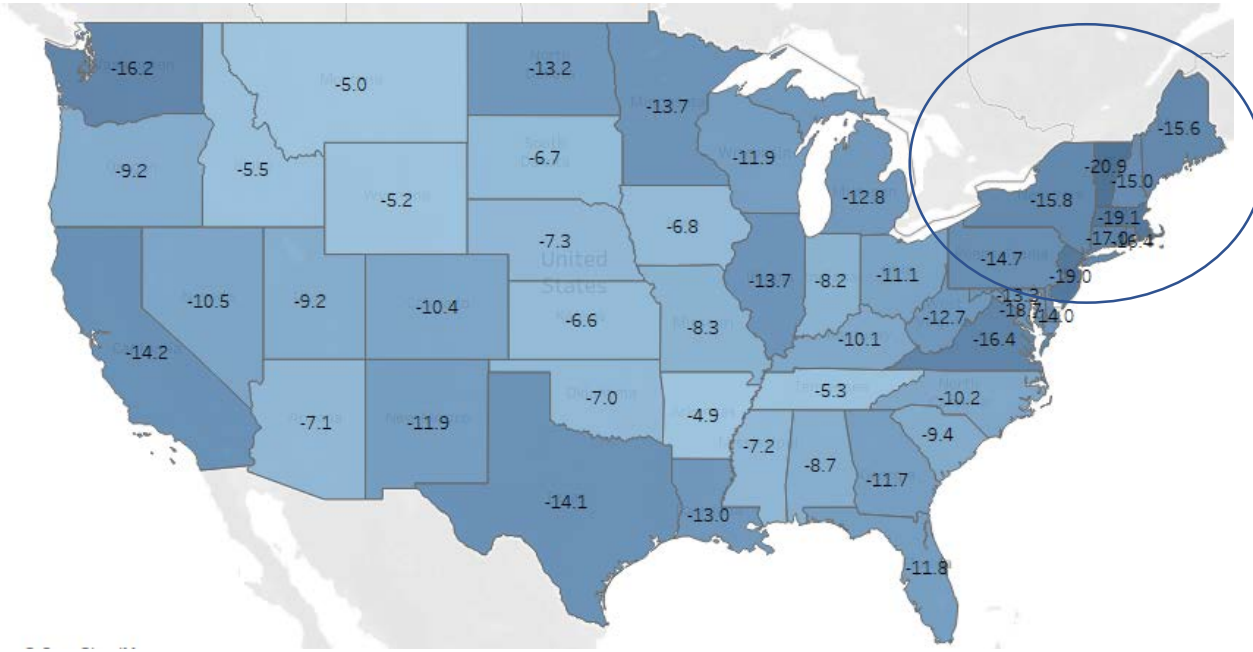
2020 had the **second highest count of site days above 90 degrees** on record

PFAS NADP Pilot results



- 30 sites analyzed for PFAS during Spring/Summer 2019
- Concentrations were low for individual compounds, but the sum of 36 compounds exceeded 4 ng/L at several sites

NOAA Summer Maximum Temperature Rank & DOT – Summer Vehicle Miles Traveled



June, July, August